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**VEHICLE SECURITY SYSTEM SHOCK SENSING
SIREN AND ASSOCIATED METHODS**

Field of the Invention

The present invention relates to the field of security systems, and, more particularly, to a vehicle security system including a siren also sensing shocks
5 and associated methods.

Background of the Invention

Vehicle security systems are widely used to deter vehicle theft, prevent theft of valuables from a
10 vehicle, deter vandalism, and to protect vehicle owners and occupants. A typical automobile security system, for example, includes a central processor or controller connected to a plurality of vehicle sensors. The sensors, for example, may detect opening of the trunk,
15 hood, doors, windows, and also movement of the vehicle or within the vehicle. Ultrasonic and microwave motion detectors, vibration sensors, sound discriminators, differential pressure sensors, and switches may be used as sensors. In addition, radar sensors may be used to
20 monitor the area proximate the vehicle.

The controller typically operates to give an alarm indication in the event of triggering of a vehicle sensor. The alarm indication may typically be a flashing of the lights and/or the sounding of the

vehicle horn or a siren. In addition, the vehicle fuel supply and/or ignition power may be selectively disabled based upon an alarm condition. A typical security system also includes a receiver associated with the controller. The receiver cooperates with one or more remote transmitters typically carried by the user and which are used to arm and disarm the vehicle security system, for example. Other remote control features, such as locking or unlocking vehicle doors may also be performed.

The alarm indication provided at the vehicle is important to the overall effectiveness of the security system. For example, a weak alarm indication may do little to deter a would-be thief. A thief may also be more likely to target a vehicle when the vehicle is among hundreds of vehicles in a large parking lot, for example. In such a situation, the thief may be comforted in knowing that the alarm indication will not be identified by the vehicle's owner, since many audible alarm indications are generic.

Another disadvantage with many conventional security systems, especially minimal feature systems as typically installed by vehicle manufacturers, is that no shock sensing capability is provided. Accordingly, the alarm will only sound for opening of the vehicle doors, for example, and not when the vehicle is towed or lifted onto a truck and carried away. Since there is no shock sensor typically on such minimal feature security systems, there is no ability to provide a prewarn alarm that is less than the full alarm. The prewarn alarm in feature-rich aftermarket security systems may desirably warn off a would-be thief before serious damage is done to the vehicle. The prewarn, if falsely triggered, is also less intrusive than a full alarm.

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Summary of the Invention

In view of the foregoing background, it is therefore an object of the present invention to provide a vehicle security system including a siren, and
5 related methods wherein shock sensing capability is more readily provided for the vehicle.

This and other objects, features and advantages in accordance with the present invention are provided by a vehicle security system including at least one security
10 sensor and a security controller connected thereto, and a siren which also serves as a shock sensor. More particularly, the siren may comprise a housing, a siren electrical signal generator circuit carried by the housing for generating an electrical siren security
15 alarm signal responsive to the security controller, and a shock detector circuit carried by the housing for processing an electrical shock sense signal for the security controller. In addition, the siren also preferably includes an electrical/mechanical (E/M)
20 transducer carried by the housing for sounding a siren security alarm responsive to the electrical siren security alarm signal, and for generating the electrical shock sense signal responsive to mechanical shock. In other words, the E/M transducer and
25 associated circuitry provide the dual alternate functions of sounding the siren security alarm and sensing for shocks to the vehicle. The siren provides a compact, portable, and readily installed device which can be used alone or to upgrade an existing vehicle
30 security system, for example.

The vehicle also typically includes an ignition switchable between ON and OFF positions. To avoid undesired alarm soundings or shock sensing, the siren may be operable responsive to the ignition being in the

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The security controller is also typically switchable between an armed mode for causing the siren to generate the siren security alarm responsive to the at least one security sensor, and a disarmed mode. In addition, the vehicle security sensor may comprise a hood switch, and the shock detector may be operatively coupled to the security controller through the hood switch to simplify installation and connection of the siren. In other words, the siren shock sense output can be coupled to the hood switch, and the siren alarm will not sound unless the security controller is in the armed mode. This is so since the hood switch will not trigger an alarm unless the controller is in the armed mode.

In some embodiments, the commonly used E/M transducer may comprise a loudspeaker. In addition, the housing of the siren may be for mounting within a vehicle engine compartment.

Another aspect of the invention relates to a method for providing vehicle security. The method may comprise connecting a siren in the vehicle, the siren
35 comprising a housing, a siren electrical signal

generator circuit carried by the housing, a shock
detector circuit carried by the housing, and an
electrical/mechanical (E/M) transducer carried by the
housing. The method may also include generating an
5 electrical siren security alarm signal using the siren
electrical signal generator circuit and sounding a
siren security alarm responsive thereto using the E/M
transducer. And the method may also include generating
the electrical shock sense signal responsive to
10 mechanical shock using the E/M transducer and
processing the electrical shock sense signal using the
shock detector circuit.

Brief Description of the Drawings

15 FIG. 1 is a schematic block diagram of a vehicle
security system including the siren in accordance with
the present invention.

FIG. 2 is a more detailed schematic block diagram
of the siren shown in FIG. 1.

20 FIG. 3 is a flowchart illustrating a first method
embodiment in accordance with the invention.

FIG. 4 is a flowchart illustrating a second method
embodiment in accordance with the invention.

25 FIG. 5 is a flowchart illustrating a third method
embodiment in accordance with the present invention.

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Detailed Description of the Preferred Embodiments

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The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

The vehicle security system **20**, including the siren **50**, in accordance with the invention is first described with reference to FIGS. 1 and 2. The security system **20** includes a vehicle security controller **22** which is illustratively positioned in the vehicle passenger compartment **23** as is typical. The security controller **22** is connected to one or more vehicle security sensors, such as sensors 1-N, **24a-24c**, respectively. As will be appreciated by those skilled in the art, these sensors **24a-24c** may be various switches or other sensors carried by the vehicle to detect attempted theft or tampering with the vehicle.

A hood switch or position sensor **24d** is also connected to the security controller **22** in the illustrated embodiment. The hood switch **24d** is typically positioned in the vehicle engine compartment **27** and detects opening of the vehicle hood as will also be readily appreciated by those skilled in the art. This hood switch **24d** may be advantageously used to interface with the security controller **22** as will be explained in greater detail below.

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A receiver **31** and its associated antenna **33** may receive signals from a handheld remote transmitter **32**. For example, the remote transmitter **32** may include one or more buttons or switches **35a-35c** carried by a housing **36**. These switches **35a-35c** may be used to arm or disarm the vehicle security controller **22**, or may be used to remotely open the vehicle trunk. The switches **35a-35c** may alternately or additionally be used to lock and unlock the vehicle doors remotely as will be readily appreciated by those skilled in the art. The housing **36** may also carry a one or more keys, such as the ignition key **37**, as shown in the illustrated embodiment.

In some embodiments, the receiver **31** may be a changing code receiver and the remote transmitter may be a changing code transmitter **32** for additional security. By changing code is meant that the remote transmitter **32** transmits at least a code portion which is pseudorandomly coded, and which is synchronized with the receiver **31**. Accordingly, merely recording a transmission from the remote transmitter **32** and playing back the transmission with a so-called "code grabber" will not operate the changing code receiver **31** as will be appreciated by those skilled in the art.

The security controller **22** is also illustratively connected to an ignition switch **44**. In addition, the security controller **22** in the illustrated embodiment provides an alarm output via the vehicle horn **45**. More particularly, the horn **45** is electrically operable by the user based upon the user selectively depressing a horn switch **43** which, in turn, selectively connects the horn to the vehicle power supply, such as the schematically illustrated vehicle battery **42**. In other

words, the horn switch **43** permits selective occasional operation of the horn **45** by the user, such as to signal other motorists or pedestrians when the user is operating the vehicle.

- 5 The vehicle security controller **22** is also connected to drive or operate the horn **45**. For example, and as will be readily appreciated by those skilled in the art, the security controller **22** may be connected to the horn **45** by splicing or connecting to
- 10 the appropriate wires as are accessible adjacent the steering column within the passenger compartment **23**. These wires pass through the firewall of the vehicle into the engine compartment **27** as will be appreciated by those skilled in the art.
- 15 The vehicle security controller **22** may operate the horn **45** in a predetermined pattern to sound the horn security alarm responsive to one or more of the security sensors **24a-24d**, such as to indicate a vehicle security breach. For example, the vehicle security
- 20 controller **22** may operate the horn **45** in a pattern including a series of operations of the horn within a predetermined time, and/or with each operation having a predetermined duration. Alternately, the security controller **22** may sound the horn **45** continuously for
- 25 longer than a predetermined time.

- The security system **20** advantageously includes a siren **50** for sounding a siren security alarm to supplement a horn security alarm responsive to operation of the horn in the predetermined pattern,
- 30 such as provided by the security controller **22**. In addition, the siren **50** preferably does not sound the siren security alarm responsive to selective occasional operation of the horn **45**, such as caused by the user pressing the horn switch **43**.

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For example, the horn operation detector circuit **53** may include a pattern detection circuit **61** (FIG. 2) which analyzes the driving signals to the horn **45** and determines whether, for example, X number of horn pulses are being provided within a given time T1, and/or whether a series of X horn pulses are being provided with each pulse having a length or duration of a predetermined time T2. The horn operation detector circuit **53** may also include a continuous pattern of operation detector circuit **62** which determines or detects whether the horn **45** is being operation for longer than a predetermined time T3. Of course, the outputs of these two pattern detector circuits **61**, **62** can be combined with the illustrated OR gate **63**, and, in turn, the output of the OR gate can be fed into an AND gate **64** which also receives the ignition OFF signal as an input.

The ignition OFF signal is illustratively provided via an inverting logic gate **65** connected to a switched positive voltage output of the ignition switch **44**, so that when the ignition is OFF, a logic ONE is input to the input of the AND gate **64**. Other logic circuitry and arrangements are contemplated by the present invention as will be appreciated by those skilled in the art.

The siren **50** by itself can be retrofitted to an existing vehicle security system **20** with only a few simple electrical connections readily made within the engine compartment **27**. The complete security system **20** can also be readily and easily installed as a complete package as will also be appreciated by those skilled in the art.

In some embodiments, the siren **50** may be further enhanced to avoid false or undesired triggering of the

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siren alarm, as when the horn 45 is manually operated by the user, by further basing sounding of the siren security alarm on the vehicle ignition switch 44 as mentioned briefly above. The vehicle typically includes the ignition switch 44 being switchable between ON and OFF positions. In accordance with this aspect of the invention, the siren 50 may sound the siren security alarm further responsive to detecting the ignition 44 being in the OFF position. In addition, the siren 50 may not sound the siren security alarm further responsive to detecting the ignition 44 being in the ON position. The horn 45 is typically manually operated by the user when driving with the ignition switch 44 in the ON position, avoiding sounding the siren security alarm with the ignition ON may also be desirable. This ignition sensing feature of the siren 50 may be used in combination with the horn operation pattern detecting, or may be used by itself.

To further aid the effective interfacing with the horn 45 and security controller 22, the siren 50 may have a start delay time so that sounding the siren security alarm is delayed after operation of the horn 45 is started. This may also reduce false or undesired triggering for manual operation of the horn 45. The siren 50 may also have a stop delay time so that sounding the siren security alarm continues only for a short time until after operation of the horn 45 is stopped. The start and/or stop delay may be implemented by the schematically illustrated start/stop delay(s) circuit 56 (FIG. 2) which may be a portion of the horn operation detector circuit 53. For example, the start delay may be 10 to 15 seconds, and, the stop

delay may be about 1 second. Other delays are also possible.

As shown in the illustrated embodiment, the siren 50 may comprise a housing 51, an audio alarm generator 5 carried by the housing for sounding the siren security alarm, and a horn operation detector or detector circuit 53 carried by the housing for detecting operation of the horn 45, such as in the predetermined pattern and for operating the audio alarm generator responsive thereto. The horn operation detector circuit 53 may also detect the position of the ignition switch 44 as described above. The audio alarm generator may include the illustrated siren electrical signal generating circuit 54, and the E/M transducer 15 55, such as a loudspeaker, connected to the siren electrical signal generating circuit. In other terms, the audio alarm generator includes the circuitry 54 for generating the electrical siren drive signal, and the E/M transducer 55 for converting the electrical energy 20 or signal into the mechanical or acoustical energy or audible signal.

The siren 50 may also include at least one energy storage device 58 (FIG. 2), such as a battery or capacitor to power the siren if power from the vehicle 25 is not available. Typically, however, the energy storage device 58 may not be needed as the siren 50 can be powered from the vehicle battery 42 or electrical system, for example.

In one particularly, advantageous embodiment, the 30 siren electrical signal generator circuit 54 may produce a multiple-tone siren pattern as disclosed in U.S. patent applications serial no. 09/374,178, filed August 13, 1999, and serial no. 09/596,547, filed June 19, 2000. The subject matter of each patent

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application is incorporated herein by reference in its entirety.

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The E/M transducer **55** may be provided by a conventional loudspeaker, for example. The E/M transducer **55** may include a metal frame **71** (FIG. 2) having a frusto-conical shape, and which mounts a high-powered permanent magnet **72** at its smaller end. A movable diaphragm **73** is also carried by the frame **71**. The diaphragm **73** is connected to a voice coil **74** adjacent the permanent magnet **72**. The voice coil **74**, in cooperation with the permanent magnet **72**, moves the diaphragm **73** responsive to the electrical drive signal from the siren electrical signal generator circuit **54**. Movement of the diaphragm **73** generates the acoustic waves or sounds for the siren security alarm indication. In other embodiments, the E/M transducer **55** may be based on piezoelectric or types of driving different than electromagnetic driving as will be appreciated by those skilled in the art.

In accordance with another advantageous feature of the invention, the siren **50** may include the illustrated shock detector circuit **80** connected to the E/M transducer **55** for determining a shock to the vehicle. The shock detector circuit **80** is also preferably carried by the housing **51**. The shock detector circuit **80** is for processing an electrical shock sense signal from the E/M transducer **55**, and for generating a siren alarm indication and/or communicating the shock determination to the vehicle security controller **22**.

The present invention takes advantage of the ability of the E/M transducer **55** to also convert mechanical or acoustic energy into electrical energy. As the diaphragm **73** is moved relative to the frame **71** by a

shock to the vehicle, an electrical signal is generated as the voice coil **74** moves in the presence of the magnetic field generated by the permanent magnet **72** as will be appreciated by those skilled in the art. U.S. Patent No. 4,383,242 to Sassover et al. discloses, for example, using the stereo speakers of a vehicle entertainment system to detect unauthorized access attempts into the vehicle. The entire disclosure of this patent is incorporated herein by reference.

10 In accordance with this aspect of the invention, the E/M transducer **55** and the associated circuitry provide the dual alternate functions of sounding the siren security alarm and sensing for shocks to the vehicle. The siren **50** thus provides a compact,
15 portable, and readily installed device which can be used alone or to upgrade an existing vehicle security system, for example.

As described herein, the vehicle also typically includes an ignition switch **44** switchable between ON
20 and OFF positions. To avoid undesired alarm soundings or shock sensing, such as when the user is entering or using the vehicle, the siren **50** may be operable as a shock sensor responsive to the ignition being in the OFF position and not operable responsive to the
25 ignition being in the ON position.

Yet another feature of the invention also relates to avoiding false or undesired alarms. The vehicle security controller **22**, as described above, is also typically switchable between an armed mode and a
30 disarmed mode, such as controlled by the remote transmitter **32**. In the armed mode, the security controller **22** causes the siren **50** and/or horn **45** to generate a security alarm responsive to the security sensors **24a-24d**. In the disarmed mode, the security

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When connected to the hood switch **24d**, and if the security controller **22** is armed, the output of the shock detector circuit **80** will cause the vehicle security controller to be triggered, thereby causing generation of the horn and/or siren security alarms. Conversely, if the security controller **22** is in the disarmed mode, the output of the shock detector circuit **80** will not cause the security controller to generate an alarm.

Connection to the nearby sensor, such as the hood switch **24d**, greatly simplifies installation. Of course, other similar false or undesired alarm bypass techniques are also contemplated by the present invention, and, indeed other sensors could be connected to, in addition to, or in place of the hood switch **24d**.

Another aspect of the invention relates to the ability of the siren **50** to provide a prewarn and full alarms in some embodiments. More particularly, the shock detecting circuit **80** may generate a first output based upon detecting a shock within a first intensity range, and may generate a second output based upon detecting a shock within a second intensity range. The first intensity range may be less than the second intensity range, and the first output may then cause a

reduced siren security alarm, or prewarn alarm, and the second output may cause the full siren security alarm.

Referring more particularly to the more detailed schematic block diagram in FIG. 2 for the shock detector circuit **80**, one approach to implement this dual shock detecting approach is now described in greater detail. The signal from the E/M transducer **55** is coupled through an amplifier **81** and filter **82** to a pair of comparators **83, 84**. The prewarn alarm comparator **83** compares the input signal against a first threshold L1, and generates a prewarn output if the input signal is greater than L1. Similarly, the full alarm comparator **84** compares the input signal to a second higher threshold L2. If the input signal is above L2, then a full alarm output is generated by the full alarm comparator **84**. Those of skill in the art will appreciate other equivalent signal detection circuits than can provide both a prewarn and full alarm output. In addition, more than two levels could also be provided. One or both of the comparators **83, 84** may also be provided with hysteresis, as will also be appreciated by those skilled in the art.

In the illustrated embodiment, the prewarn output from the prewarn alarm comparator **83** is connected to the siren electrical signal generator circuit **54**. Accordingly, the siren **50** may generate a short chirp prewarn signal from the E/M transducer **55** after a prewarn level shock has been detected.

As also shown in the illustrated embodiment, the full alarm comparator **84** may have its output coupled to the hood switch **24d** as described above to couple to the vehicle security controller **22**. In yet other embodiments, both outputs could be coupled to the siren electrical signal generator **54** or both outputs could be

connected to the vehicle security controller **22** as will also be appreciated by those skilled in the art.

Turning now additionally to the flowchart of FIG. 3 a method aspect of the invention is now described as

5 relates to a method for supplementing a horn security alarm in a vehicle. The vehicle is of a type including a horn **45** being electrically operable, a horn switch **43** permitting selective occasional operation of the horn by a user, at least one security sensor **24a-24d**, and a

10 security controller **22** for operation of the horn to sound the horn security alarm responsive to the at least one security sensor. From the start (Block **100**), the method may comprise monitoring the horn **45** for operation at Block **102**, and sounding the siren security alarm

15 (Block **110**) to supplement the horn security alarm responsive to detecting operation of the horn **45** in a predetermined pattern. The operation of the horn may be analyzed to determine whether an X number of pulses have been detected within time T1 at Block **104**. If so, the

20 siren security alarm is sounded (Block **110**). If not, the horn operation is analyzed to determine if each of X pulses has a time duration of T2 at Block **106**. If so, the siren security alarm is sounded. If not, then at Block **108** it is determined whether the horn is being

25 continuously operated for longer than a time T3, and, if so, the siren security alarm is sounded. Accordingly, the siren security alarm is sounded when the horn **45** is operated in a predetermined pattern, such as would occur under control of the vehicle security controller **22**, and

30 the siren security alarm is prevented from sounding responsive to selective occasional operation of the horn, such as by the user.

In one embodiment, analyzing or considering the horn pulses to determine the predetermined pattern may

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As discussed above, sounding the siren security alarm at Block **110** can be delayed based upon a start-up delay time. In addition, while the siren security alarm is being sounded, it may be desirable to continue to monitor the horn operation (Block **112**) to determine whether the horn has stopped at Block **114**. If not, the siren security alarm continues and the horn is also monitored until stoppage of the horn is detected at Block **114**. The siren security alarm may be stopped at Block **116** before ending at Block **118**. Of course, a stop delay may also be provided before stopping sounding of the siren security alarm (Block **116**).

Another aspect of the invention relates to monitoring the ignition **44** in addition to the horn **45**, as explained with reference to the flowchart of FIG. 4. From the start (Block **130**) both the horn **45** and the ignition switch **44** are monitored at Block **132** and Block **134**, respectively. If both the horn is being operated

(Block 136) and the ignition is OFF (Block 138) as determined at Block 140, the siren security alarm may be sounded at Block 142. Of course, the siren may be sounded after a start delay if desired.

5 The siren will continue to sound until monitoring the horn (Block 144) indicates that the horn has stopped (Block 146). The siren security alarm may then be stopped at Block 148 before ending (Block 150). The stop delay may also be provided. In this illustrated
10 embodiment, the sounding of the siren security alarm is based upon both the ignition switch 44 being OFF and the horn 45 being operated. The concept of determining that the horn 45 is being operated in a predetermined pattern can also be combined with the ignition monitoring in
15 accordance with the invention as will be understood by those skilled in the art.

Turning now additionally to the flowchart of FIG. 5, the shock sensing feature of the present invention will be further described. From the start (Block 160),
20 the E/M transducer 55 may be monitored for operation by the siren electrical signal generator circuit 54 (Block 132), and while the ignition switch 44 is also monitored (Block 164). If the E/M transducer 55 is sounding, the shock sensing feature is, of course, bypassed (Block
25 166). Also, in the illustrated embodiment, if the ignition switch is ON (Block 168), the shock sensing feature is also bypassed. If, however, the E/M transducer 55 is idle, and the ignition switch 44 is OFF as determined at Block 170, then the E/M transducer is
30 monitored at Block 172 for shock signals.

If the shock signal is greater than a first threshold or value L1 (Block 174), a prewarn output may be given at Block 176. If the shock signal is also

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greater than a second threshold or value L2 (Block **178**),
the a full siren security alarm output may be given at
Block **180**, before stopping at Block **182**. Both outputs
could be given for the higher threshold shock or the
5 prewarn output could be suppressed. In addition, the
prewarn and full alarm output signals could be
multiplexed for communication over a single pair of
wires to the vehicle security controller **22** as will be
readily appreciated by those skilled in the art. Other
10 details and aspects of this method of the invention are
described in greater detail above, and require no
further description at this time.

Considered in somewhat different terms, this method
aspect may include connecting a siren **50** in the vehicle,
15 the siren comprising a housing **51**, a siren security
alarm generator circuit **54** carried by the housing, a
shock detector circuit **80** carried by the housing, and an
E/M transducer **55** carried by the housing. The method
may also include generating an electrical siren security
20 alarm signal using the siren security alarm generator **54**
and sounding a siren security alarm responsive thereto
using the E/M transducer **55**. The method may also
include generating the electrical shock sense signal
responsive to mechanical shock using the E/M transducer
25 **55** and processing the electrical shock sense signal
using the shock detector circuit **80**.

Many modifications and other embodiments of the
invention will come to the mind of one skilled in the
art having the benefit of the teachings presented in the
30 foregoing descriptions and the associated drawings.
Therefore, it is to be understood that the invention is
not to be limited to the specific embodiments disclosed,
and that other modifications and embodiments are

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intended to be included within the scope of the appended claims.

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